DOCUMENT RESUME

ED 231 509 PS 013 582

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TITLE Encoding Variability and the Development of Rehearsal.
PUB DATE Mar 83
NOTE 22p.; Paper presented at the Annual Meeting of the Southeastern Psychological Association (Atlanta, GA, March 24-26, 1983).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Associative Learning; Cues; Elementary Education; *Elementary School Students; Grade 3; Grade 6; *Performance Factors; *Recall (Psychology)
IDENTIFIERS Rehearsal (Memory); *Rehearsal Strategies

ABSTRACT

A study was conducted to test the hypothesis that high-variability rehearsal more effectively facilitates word recall than does low-variability rehearsal. Third-grade and sixth-grade students were asked to memorize a list of 20 common words. A read-aloud rehearsal procedure was used so that rehearsal could be experimentally controlled. One word was presented every 5 seconds; on the same card, the rehearsal accompanying it was also presented. As each card was shown, the experimenter read the to-be-remembered word aloud, and then the child read the rehearsal aloud. The high-variability rehearsal protocols consisted of the word to be remembered plus the previous two items. The low-variability rehearsal protocols were designed so that any given item was likely to be rehearsed along with only two other items. Free recall was tested after each of four study/test trials, and a form of cued recall was measured at the end of the session. Results showed that sixth graders consistently remembered more words than did third graders. Both third and sixth graders recalled more words in the high-variability rehearsal condition. Also, results of the cued recall test suggested that more inter-item associations were developed through reading the high-variability rehearsal. (RH)

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ENCODING VARIABILITY AND THE DEVELOPMENT OF REHEARSAL

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Richard G. Medlin

Paper presented at the meetings of the Southeastern Psychological Association March 24-26, 1983, in Atlanta, Georgia

Introduction

If you ask elementary school children how they memorize things, you are likely to get answers such as these: "I read it three times" or "I say it out loud to my mother over and over and she tells me if I'm right or not" or "I practice it for ten minutes and then I know it." And all of these answers tell you pretty much the same thing: when elementary school children must memorize something, they rehearse it, that is, they encode it or act upon it repeatedly.

Now, if you ask these children to actually memorize a list of words in a standard task, you find that they do indeed rehearse the words, and that younger children rehearse differently than older children do. Younger children are likely to rehearse words in what has been called a "passive," rote way. They rehearse each word on the list in isolation, repeating only the one word that is being shown to them at a time. Each rehearsal "set" contains only one item, as shown in the first slide (SLIDE 1). Older children, however, use what has been described as "active" rehearsal. They group the words and intermingle them, constantly bringing back old items to rehearse along with the new ones. Their rehearsal is more cumulative, and each rehearsal set includes three or four items. Of course, not only do older children rehearse differently than younger children, they also remember more of the words. A great deal of research suggests that the more items per rehearsal set there are, that is the more "active" the

rehearsal is, the more effective it is (Medlin, 1980; Naus, Ornstein & Aivano, 1977; Ornstein & Naus, 1978a; Ornstein, Naus & Liberty, 1975; Ornstein, Naus & Stone, 1977).

What is it about "active" rehearsal that makes it effective? The literature suggested to me that perhaps the degree to which items were intermixed, or the "variability" of rehearsal, was perhaps more critical for recall than the number of items per set, or the "activity" of rehearsal. "Active" rehearsal tends to ensure some variability, because items are rehearsed in ever-changing groups rather than just one at a time. It also occurred to me how similar this rehearsal variability idea was to the concept of encoding variability (see Crowder, 1976). The encoding variability concept states that an item encoded twice in a different context each time is more likely to be recalled than an item encoded twice in the same context each time, because the contexts serve as cues for recall. Presenting material repeatedly in different contexts gives more cues for recall because there is more contextual information associated with the material.

It seemed to me that the concept of encoding variability could be easily adapted to explain rehearsal variability. In mature, effective rehearsal, items are rehearsed in groups, and the items which are included in these groups change from set to set. Thus, any given item is usually rehearsed in more than one set and the other words rehearsed along with it vary from one set to another. This appeared to be analogous to the repeated

encoding of items with contextual variability. I thought it was possible that this rehearsal variability could establish associations among the items that are rehearsed together, just as encoding variability establishes associations between material and its encoding contexts. So, the hypothesis addressed by the present research was this: variability in rehearsal improves recall because it causes multiple associations among the items on a list to be established, and thus the recall of one item can cue the recall of other items.

Method

Children at two age levels were asked to memorize a list of 20 common words. The third graders were almost nine years old; the sixth graders were just over eleven and a half years old. A read-aloud rehearsal procedure was used so that rehearsal could be experimentally controlled (see Ornstein & Naus, 1978b). One word was presented every five seconds, and as it was presented, the rehearsal accompanying it was also presented on the same card. As I showed each child the card, I read the to-be-remembered word aloud, and then the child read the rehearsal aloud. This slide (SLIDE 2) shows what the first few cards looked like for one group. Of course, subjects saw only one card at a time.

After all 20 cards had been presented and the rehearsal on each read aloud, subjects were asked to recall as many of the words as possible in any order. The entire procedure was

repeated for a total of four trials, (with each subject seeing exactly the same cards all four times.) Following free recall on the final trial, one unrecalled item from the list was randomly selected and presented to the subject as a cue to see if any other previously unrecalled items could then be recalled, as would be expected if inter-item associations existed. The dependent measures, then, were free recall and this type of cued recall.

The manipulation of interest was the kind of rehearsal that was being read aloud. The read-aloud rehearsal was designed to simulate rehearsal with either a very high or a very low degree of variability. All of the rehearsal sets consisted of three different items, the current item plus two other previous items from the list. The only major difference between the two types of rehearsal was the degree to which items were intermixed over the course of a trial. Examples of the two kinds of rehearsal are shown in this next slide (SLIDE 3).

The high-variability rehearsal protocols maintained a high degree of intermixing by including each item along with the previous two items in each rehearsal set. The words that were practiced together were constantly changing, and over the course of a trial each item was rehearsed along with several others. The next slide (SLIDE 4) shows the entire high-variability rehearsal protocol.

The low-variability rehearsal protocols, in contrast, were

designed to minimize the degree to which items were intermixed. This was accomplished by repeating the same few items over and over again in many rehearsal sets. Each set contained three items, but across sets, two of those items were likely to be the same, as you can see in this slide (SLIDE 5). Any given item was likely to be rehearsed along with only two other items altogether. The purpose was to try to maximize the number of inter-item associations in high-variability rehearsal, and to minimize the number of associations in the low-variability rehearsal.

In summary, a simple two-by-two design was used (SLIDE 6). Third- and sixth-grade children read aloud rehearsal that was designed for either high or low variability. Free recall was tested after each of four study-test trials, and a form of cued recall was measured at the very end of the session.

Results

The results showed that sixth graders consistently remembered more words than third graders no matter what kind of rehearsal they were reading. This slide (SLIDE 7) shows the mean number of words recalled per trial in the free recall test. This age effect was found to be significant in an analysis of variance (with age and type of rehearsal as the factors and free recall as the dependent variable). The type-of-rehearsal effect was also significant as both third and sixth graders recalled more words if they were reading high-variability rehearsal than

if they were reading low-variability rehearsal. (The interaction was not significant).

The age and type-of-rehearsal effects can also be seen in the serial position curves (SLIDE 8). These figures show the probability of recall plotted as a function of the items' serial position in the list, with serial position treated in blocks of two. (In other words, the first point in the curve, over on the left, represents the probability of recall for the first and second items in the list. The second point, moving to the right, represents recall of the third and fourth items on the list, and so on.)

You can see that the recall curves of the sixth grade groups, drawn with open circles, are higher than those of the third grade groups, drawn with solid circles, in both figures. This is, of course, the age effect. Now compare the low-variability rehearsal recall curves, in the top figure, with the high-variability rehearsal recall curves in the bottom figure. The relatively flat portion in the middle of each recall curve is higher for the high-variability rehearsal groups than for the low-variability groups. This difference occurred because the overall level of recall was higher for the high-variability rehearsal groups. Also, the recall curves for the high-variability groups are more rounded at each end, showing that the primacy and recency effects included not just the first two or last two items, but also the adjacent items.

Reading high-variability rehearsal improved recall, but

why? The hypothesis under investigation was that high-variability rehearsal would develop more inter-item associations than low-variability rehearsal, and so recall would improve because remembering one item would cue the recall of others. The cued recall data supported this hypothesis (SLIDE 9). In the cued recall test, subjects were cued with a word from the list that they had never remembered during free recall, and they were trying to come up with other words that they had also never recalled. Therefore, the overall number of words recalled was quite low, as you can see. However, subjects reading the high-variability rehearsal recalled significantly more words after the presentation of the cue. This result suggests that more inter-item associations were developed through reading the high-variability rehearsal.

Two other methods were also used to investigate this inter-item association hypothesis. In these analyses, the order in which words were recalled was compared to the way that they were rehearsed. If rehearsal did build up inter-item associations, then words should have been recalled in groupings similar to those in which they were rehearsed. Only the high-variability groups rehearsed items in sequential groupings, that is, items 3-4-5 together, then 4-5-6 together, then 5-6-7 together, and so on. The low-variability groups rehearsed groupings such as 1-2-5, 1-2-6, 2-6-7, 1-2-8 and so on. Did the children recall items the same way?

The first analysis to address this question simply iden-

tified groupings of sequentially contiguous items in recall, regardless of order. That is, recalling the third item in the list, and then the fifth, and then the fourth would be treated as a recall unit of size three. Children reading high-variability rehearsal recalled more of these sequential units, recalling 35 pairs, 22 triplets, 9 units of size four, and one unit each of sizes five and six. Children reading low-variability rehearsal recalled about the same number of pairs, but only one unit of any larger size. They were, however, likely to recall items 1 and 2 together, and items 2 and 6 together. Those were the only groupings that repeatedly appeared in the low-variability rehearsal.

Of course, since the overall level of recall was higher for the high-variability rehearsal groups, they would be more likely to recall words in such groupings simply by chance. A second analysis took the overall level of recall into account. For each subject, a target item was randomly selected from the trial-four recall protocol. Then it was determined whether or not the item immediately following the target item on the list was also recalled, and if it was, whether or not it was recalled in a pair with the target item. (For example, let's say that item number seven was randomly selected from one subject's recall protocal as the target item. I would first look to see if item eight was also recalled. If it was, I would determine whether or not it was recalled immediately before or after item seven was recalled, thus making a pair.)

There were, then, two measures of probability: (1) given that X was recalled, was Y also recalled? and (2) given that X and Y were both recalled, were they recalled together as a pair? It was possible to determine what these probabilities would be expected to be by chance given the total number of words recalled, and it was possible to determine the observed probabilities for these events in each group. This slide (SLIDE 10) shows the results of the analysis.

In the top part of the table, you can see the expected and observed probabilities for the recall of Y given the recall of X. The expected-observed differences were higher for the high-variability groups as predicted, but these differences were not significant. The bottom part of the table shows the expected and observed probabilities for recalling X and Y together as a pair, given that both were recalled. The expected-observed differences were again higher for the high-variability groups as predicted, and in this case the differences were significant. So, once again, the subjects reading the high-variability rehearsal were more likely to recall items in the same groupings in which they were rehearsed.

Conclusions

In conclusion, increasing the variability of rehearsal improved recall even when other aspects of rehearsal were held constant. This variable rehearsal worked because it developed inter-item associations which could serve as cues for recall.

This research suggests that rehearsal is effective to the extent that it creates interrelationships within the to-be-remembered material. The more interrelationships that are established, the more cues there are for recall. It is interesting to note that older children spontaneously rehearse with more variability than younger children. Thus rehearsal variability can account for part of the frequently observed developmental improvement in memory.

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Word Presented	Third Grader's Rehearsal	Sixth Grader's Rehearsal
Egg	Egg, egg, egg.	Egg.
Sand	Sand, sand, sand.	Egg, sand, egg sand.
Gift	Gift, gift, gift.	Egg, sand, gift, gift, sand, egg.
Rope	Rope, rope, rope.	Egg, gift, sand, rope.
Fire	Fire, fire, fire, fire.	Egg, gift, sand, rope fire.
King	King, king, king.	Gift, rope, fire, king.

EGG

egg egg

SAND

egg sand
egg sand

GIFT

egg sand gift
egg sand gift

ROPE

sand gift rope
sand gift rope

FIRE

gift rope fire
gift rope fire

KING

rope fire king
rope fire king

DESK

fire king desk
fire king desk

and so on

Examples of Read-Aloud Rehearsal

Low-variability rehearsal

SET	WORD	REHEARSAL
1	egg	egg egg
2	sand	egg sand sand sand
3	gift	egg sand gift egg gift gift
4	rope	egg sand rope rope rope rope
5	fire	egg sand fire egg sand fire
6	king	egg sand king king king king

High-variability rehearsal

SET	WORD	REHEARSAL
1	egg	egg egg
2	sand	egg sand egg sand
3	gift	egg sand gift egg sand gift
4	rope	sand gift rope sand gift rope
5	fire	gift rope fire gift rope fire
6	king	rope fire king rope fire king

High Variability Rehearsal Protocol

1. egg egg
2. egg sand egg sand
3. egg sand gift egg sand gift
4. sand gift rope sand gift rope
5. gift rope fire gift rope fire
6. rope fire king rope fire king
7. fire king desk fire king desk
8. king desk map king desk map
9. desk map name desk map name
10. map name lake map name lake
11. name lake arm name lake arm
12. lake arm house lake arm house
13. arm house job arm house job
14. house job ball house job ball
15. job ball paint job ball paint
16. ball paint cat ball paint cat
17. paint cat word paint cat word
18. cat word train cat word train
19. word train year word train year
20. train year inch train year inch

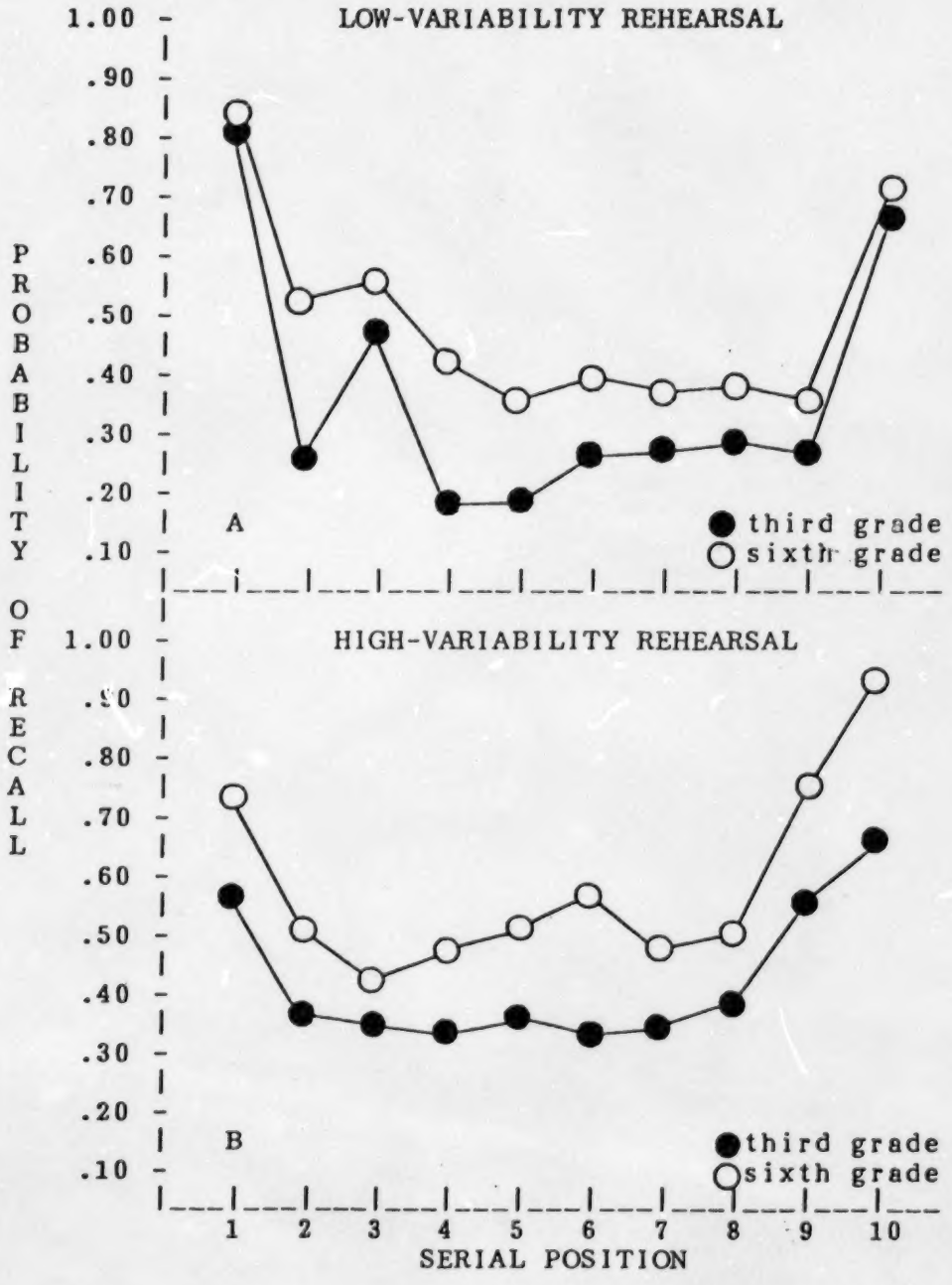
Low Variability Rehearsal Protocol

1. egg egg
2. egg sand sand sand
3. egg sand gift egg gift gift
4. egg sand rope rope rope rope
5. egg sand fire egg sand fire
6. egg sand king king king king
7. sand king desk sand desk desk
8. egg sand map map map map
9. egg sand name egg sand name
10. egg sand lake lake lake lake
11. sand king arm sand arm arm
12. sand king house house house house
13. sand king job sand king job
14. sand king ball sand ball ball
15. egg sand paint paint paint paint
16. egg sand cat egg cat cat
17. egg sand word egg sand word
18. egg sand train train train train
19. egg sand year egg sand year
20. egg sand inch egg inch inch

REHEARSAL VARIABILITY	GRADE: Third	GRADE: Sixth
Low	1	2
High	3	4

Mean Number of Words
Recalled per Trial

GROUP	GRADE	REHEARSAL VARIABILITY	Mean	SD
1	3	Low	7.67	1.55
2	6	Low	9.80	2.68
3	3	High	8.96	1.88
4	6	High	11.12	1.65



Plots of the probability of recall by serial position (blocks of two) for the low-variability rehearsal groups (panel A) and for the high-variability groups (panel B).

Mean Number of Words
Recalled after the Cue

GROUP	GRADE	REHEARSAL VARIABILITY	Mean	SD
1	3	Low	.08	.29
2	6	Low	-0-	-0-
3	3	High	.58	.90
4	6	High	.30	.68

Analyses of the Order in Which Items Were Recalled in Comparison to the Order in Which They Were Rehearsed

GROUP	GRADE	VARIABILITY	PROBABILITY EXPECTED	PROBABILITY OBSERVED	
GIVEN THAT X WAS RECALLED, WAS Y ALSO RECALLED?					
1	3	Low	.49	.50	
2	6	Low	.62	.67	
3	3	High	.58	.67	
4	6	High	.77	.92	
GIVEN THAT X AND Y WERE RECALLED, WERE THEY RECALLED TOGETHER AS A PAIR?					
1	3	Low	.18	.17	
2	6	Low	.18	.38	
3	3	High	.21	.88	*
4	6	High	.14	.55	**

* The expected-observed difference is significant, $t(7) = -4.84$, $p<.01$.

** The expected-observed difference is significant, $t(10) = -2.51$, $p<.04$.